Mars Pathfinder Project

Alpha Proton X-Ray Spectrometer (APXS) Experiment Data Record (EDR) Specification

D-12849

Version 1.1

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ACRONYMS AND ABBREVIATIONS

APID	Application Packet Identification
APXS	Alpha Proton X-Ray Spectrometer
EDR	Experiment Data Record
LSB	Least Significant Byte first architecture
MIPS	Multimission Image Processing Subsystem
PDS	Planetary Data System
TBD	To Be Determined
URL	Universal Resource Locator
VICAR	Video Image Communication and Retrieval system

ACTION ITEMS FOR CLOSURE

Item	Pages	Assignee	Closure Date
none			

1.0 INTRODUCTION

This specification describes the data products to be delivered to the Alpha Proton X-Ray Spectrometer (APXS) Team of the Mars Pathfinder Project by the Multimission Image Processing Subsystem (MIPS). The specifications of the software that produce the products described herein are beyond the scope of this document. Applicable documents include

1) Planetary Data System Standards Reference, JPL D-7669, Part 2, version 3.0, November 1992,
2) Planetary Science Data Dictionary Document, JPL D-7116, Revision C, November 1992,
3) Mars Pathfinder Rover Telemetry Dictionary, J. Morrison, A. Mishkin, Mars Rover DFM 94-033, Revision A, July 1994,
4) Mars Pathfinder Rover APXS Electrical and Control ICD, A. Mishkin, RVDFM 94-042 , Revision A, June 14, 1994,
5) VICAR File Format, JPL, R. Deen, Interoffice Memorandum 384-92-196, September 1992

1.1 Product and Transferal Mechanism

The APXS spectrum data files and labels generated by MIPS software for Mars Pathfinder will be transferred electronically to the APXS Team. Each file will be generated in VICAR header and file format. A separate, detached Planetary Data System (PDS) label file will be associated with each data file, but not delivered to the APXS Team. The data files may be generated on any one of the following platforms: Sun Sparcstations with Solaris, Sun Sparcstation with SunOS, Silicon Graphics with IRIX.

1.2 Instrument Data Processing

The data packaged in the files will be unprocessed APXS result experiment data. A VICAR header will be attached to the data file. Table 1 describes the applications used in the production of APXS EDR files.

Table 1. — *VICAR Software for Mars Pathfinder APXS Spectrum Data Files*

Application	Description
MPFTELEMPROC	Fetches the Standard Formatted Data Unit (SFDU) records from the Telemetry Delivery Subsystem (TDS), and reconstructs the spectrum data file from the telemetry data. This application produces a VICAR image file with a subset of descriptive label items. It also accesses the catalog (or SPICE kernels) to supplement the ancillary information from the telemetry data.

2.0 DETAILED SPECIFICATION

The following section describes in greater detail the files to be received by the APXS Team.

2.1 Structure and Organization Overview

For each set of APXS spectrum data, two files are created: 1) spectrum data file, and 2) a detached PDS label. These files together constitute a set of data to be managed and archived within MIPS as one unit. The naming convention of these files must be retained as they are copied or moved in order to properly maintain the APXS spectrum and ancillary data (see section 2.2).

2.1.1 Spectrum Data File

A spectrum data file is organized as a VICAR file and consists of two major parts: the data file header or VICAR label, which describes what the file is, and nominally four spectrum counts (arrays) of 256 unsigned 16-bit numbers each stored in a VICAR file image area. Figure A describes this structure graphically.

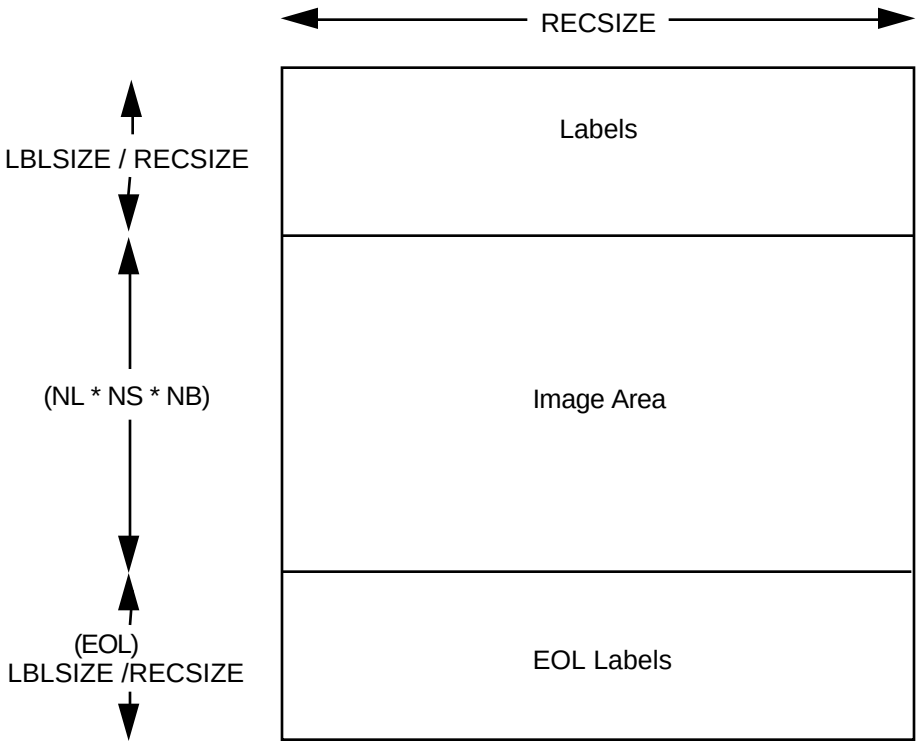

Figure A. — *VICAR File Structure for an APXS Spectrum Data File*

In Figure A, NL is the number of image lines; NS is the number of image samples per line; and NB is the number of image bands. LBLSIZE is the total number of bytes within the VICAR label, and RECSIZE is the total number of bytes per file record.

2.1.1.1 Data File Header

Within every spectrum data file, there is a VICAR header or label. This label is organized in an ASCII, keyword-equals-value format and contains information regarding the observation which produced the spectrum data. This observation information includes general descriptors such as Rover X, Y position, Rover heading, error state flags, contact sensor state, and temperature sensor readings. The following text is a direct excerpt from the VICAR File Format memorandum [5], which is available on MIPS' homepage at URL http://www-mipl.jpl.nasa.gov/vic_file_fmt.html.

> The labels (VICAR) are potentially split into two parts, one at the beginning of the file, and one at the end. Normally, only the labels at the front of the file will be present. However, if the EOL keyword in the system label (described below) is equal to 1, then the EOL labels (End Of file Labels) are present. This happens if the labels expand beyond the space allocated for them. The VICAR file is treated as a series of fixed-length records, of size RECSIZE (see below). The image area always starts at a record boundary, so there may be unused space at the end of the label, before the actual image data starts.
>
> The label consists of a sequence of "keyword=value" pairs that describe the image (or data file), and is made up entirely of ASCII characters. Each keyword-value pair is separated by spaces. Keywords are strings, up to 32 characters in length, and consist of uppercase characters, underscores (_), and numbers (but should start with a letter). Values may be integer, real, or strings, and may be multiple (e.g. an array of 5 integers, but types cannot be mixed in a single value). Spaces may appear on either side of the equals character (=), but are not normally present. The first keyword is always LBLSIZE, which specifies the size of the label area in bytes. LBLSIZE is always a multiple of RECSIZE, even if the labels don't fill up the record. If the labels end before LBLSIZE is reached (the normal case), then a 0 byte terminates the label string. If the labels are exactly LBLSIZE bytes long, a null terminator is *not necessarily* present. The size of the label string is determined by the occurrence of the first 0 byte, or LBLSIZE bytes, whichever is smaller.
> If the system keyword EOL has the value 1, then End-Of-file Labels exist at the end of the image area (see above). The EOL labels, if present, start with another LBLSIZE keyword, which is treated exactly the same as the main LBLSIZE keyword. The length of the EOL labels is the smaller of the length to the first 0 byte or the EOL's LBLSIZE. Note that the main LBLSIZE does *not* include the size of the EOL labels. In order to read in the full label string, simply read in the EOL labels, strip off the LBLSIZE keyword, and append the rest to the end of the main label string.

Figure B shows a template that describes the displayed format of this VICAR label. All keywords are described in detail in the Appendix. Note that delivered spectrum data files may have keywords listed in a slightly different order than what is shown here.

Figure B. — *VICAR Label Listing for Mars Pathfinder APXS EDR*

```
************ File apxnnnnn.dat ************
      3 dimensional IMAGE file
      File organization is BSQ
      Pixels are in HALFWORD format from a <host type> host
      1 band
      4 lines per band
      512 samples per line
      0 lines of binary header
      0 bytes of binary prefix per line

---- Property: RVR_COMMANDS ----
APPLICATION_PACKET_IDENTIFICATION = nnn
APID_DESCRIPTION = 'string describing the purpose of observation'
COMMAND_SEQUENCE_NUMBER = nnnnn
COMMAND_SEQUENCE_PARTITION = n
```

Figure B. — *VICAR Label Listing for Mars Pathfinder APXS EDR (continued)*

```
---- Property: OBSERVATION ----
MISSION_NAME = 'MARS PATHFINDER'
SPACECRAFT_NAME = 'PATHFINDER ROVER'
INSTRUMENT_NAME = 'Alpha Proton X-Ray Spectrometer (APXS)'
SPACECRAFT_CLOCK_START_COUNT= nnnnnnn
START_TIME='yyyy-mm-ddThh:mm:ss.mmm'
ALPHA_SAMPLING_DURATION = nnnnnn
XRAY_SAMPLING_DURATION = nnnnnn
PROTON_SAMPLING_DURATION = nnnnnn
BACKGROUND_SAMPLING_DURATION = nnnnnn
ROVER_POSITION = (x.xxxxexx,x.xxxxexx)
ROVER_HEADING = x.xxex
LINEAR_ACCELEROMETER_READINGS = (x.xxxxexx,x.xxxxexx)
START_ERROR_STATE = nnnnn
STOP_ERROR_STATE = nnnnn
CONTACT_SENSOR_STATE = nnnnn
SENSOR_TEMPERATURE = <array of 13 8-bit integers>
CONVERTER_CURRENT =nnn
CONVERTER_VOLTAGE = nnn
APXS_MECHANISM_ANGLE = nnn
APXS_COMMUNICATION_ERROR_COUNT = nnnnn

---- Task: MPFTELEMPROC -- User: <username> -- <date and time for product creation >----
RECEIVED_PACKETS = nnnn
EXPECTED_PACKETS = nnnn
PRODUCT_ID = 'annnnnn'
PRODUCT_CREATION_TIME = 'yyyy-mm-ddThh:mm:ss.mmm'
SOFTWARE_VERSION_ID = 'Version of MIPS telemetry processing software used'
TLM_CMD_DISCREPANCY_FLAG = <'TRUE' or 'FALSE'>
```

2.1.1.2 Spectrum Data

Within the VICAR data file is the spectrum data, which is stored as image lines within a VICAR file. Each image line corresponds to one spectrum data array. Table 2 shows the correspondence between the VICAR lines and the spectra.

Table 2. — *Mars Pathfinder APXS Spectrum Data Files*

VICAR Image Line	Spectrum	Data Format Description
1	Alpha	unsigned 16-bit array of 256 elements {least significant byte first (LSB)} Element 1 of this data array contains the accumulation time (a.k.a. ALPHA_SAMPLING_DURATION) for this spectrum in units of 10 seconds. Element 2 contains the address and complement of the spectrum, which is an internal check.
2	Proton	unsigned 16-bit array of 256 elements (LSB) Element 1 of this data array contains the value zero. Element 2 contains the address and complement of the spectrum, which is an internal check.
3	X-ray	unsigned 16-bit array of 256 elements (LSB) Element 1 of this data array contains the accumulation time (a.k.a. XRAY_SAMPLING_DURATION) for this spectrum in units of 10 seconds. Element 2 contains the address and complement of the spectrum, which is an internal check.
4	Background	unsigned 16-bit array of 256 elements (LSB) Element 1 of this data array contains the value zero. Element 2 contains the address and complement of the spectrum, which is an internal check.

In circumstances when telemetry packets are lost and not recovered for subsequent processing within the MIPS, spectrum data is also lost and therefore a subset of the spectrum arrays may be zero-filled. Thus, accumulation times, internal checks, and remaining data array elements for those lost spectrums will be zero.

2.1.2 PDS Detached Label File

For every spectrum data file, there is a corresponding PDS detached label file. This file adheres to the Planetary Data System standard for ancillary data management. The file contains information regarding the observation which produced the spectrum data. This observation information includes general descriptors such as Rover X, Y position, Rover heading, error state flags, contact sensor state, and temperature sensor readings.

The PDS label file is an object-oriented file; the object to which the label refers is denoted by a statement of the form:

```
^object = location
```

in which the carat character (^, also called a pointer in this context) indicates that the object starts at the given location. In a detached label, the location denotes the name of the file containing the object, along with the starting record or byte number, if there is more than one object. For example:

```
^ALPHA = ("annnnnn.dat",3)
```

indicates that the object begins at record 3 of the file annnnnn.dat, in the same directory as the detached label file.

All detached labels contain 80-byte fixed-length records, with a carriage return character (ASCII 13) in the 79th byte and a line feed character (ASCII 10) in the 80th byte. This allows the files to be read by the HFS, MacOS, DOS, OS2, Unix, and VMS operating systems. Also, all PDS label files have a file extension of ".lbl".

Figure C shows the template of the APXS EDR detached PDS label. See the Appendix for detailed definitions and formatting information for the label items. Also note that label item values that are capitalized or that are enclosed in quotes and not italicized represent label item values to be written verbatim.

Figure C. — *Template of Mars Pathfinder APXS EDR PDS Label File*

```
/* File Format and Length */
PDS_VERSION_ID                = PDS3
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 512
FILE_RECORDS                  = 4

/* Image Description */
MISSION_NAME                          = "MARS PATHFINDER"
SPACECRAFT_NAME                       = "PATHFINDER ROVER"
INSTRUMENT_NAME                       = "Alpha Proton X-Ray Spectrometer (APXS)"
RECEIVED_PACKETS                      = nnnn
EXPECTED_PACKETS                      = nnnn
DATA_SET_NAME                         = "Mars Pathfinder Mars Alpha Proton X-Ray
                                          Spectrometer Level 2 Experiment Data
                                          Record Version x.x"
DATA_SET_ID                           = "MPF-M-APXS-2-EDR-V1.0"
PRODUCT_ID                            = "a<command_sequence_partition>
                                          <command_sequence_number>"
PRODUCT_CREATION_TIME                 = yyyy-mm-ddThh:mm:ss.fff
PRODUCER_ID                           = "APXS Team/MIPS"
PRODUCER_FULL_NAME                    = "Mars Pathfinder APXS Team in concert with
                                          the Multimission Image Processing Subsystem"
PRODUCER_INSTITUTION_NAME             = "Jet Propulsion Laboratory (JPL)"
SOFTWARE_VERSION_ID                   = "Version of MIPS telemetry processing software used"
TLM_CMD_DISCREPANCY_FLAG              = "Indicator of mismatches between commands and telem."
```

Figure C. — *Template of Mars Pathfinder APXS EDR PDS Label File (continued)*

```
/* Time tags and observation descriptors */
APPLICATION_PACKET_IDENTIFICATION        = nnn
APID_DESCRIPTION                         = "string describing the  purpose of observation"
MESSAGE_PACKET_NUMBER                    = nnnnn
COMMAND_SEQUENCE_NUMBER                  = nnnnn
COMMAND_SEQUENCE_PARTITION               = n

/* CCSDS time at which packet is generated on Lander */
SPACECRAFT_CLOCK_START_COUNT             = nnnnnnn
START_TIME                               = yyyy-mm-ddThh:mm:ss.fff

/* Rover spacecraft position and heading */
ROVER_POSITION                  = (x.xxxxexx, x.xxxxexx)
ROVER_HEADING                   = x.xxexx
LINEAR_ACCELEROMETER_READINGS   = (x.xxxxexx, x.xxxxexx)

/* Other readings and values*/
ALPHA_SAMPLING_DURATION                  = nnnnnn
XRAY_SAMPLING_DURATION                   = nnnnnn
START_ERROR_STATE                        = nnnnn
STOP_ERROR_STATE                         = nnnnn
CONTACT_SENSOR_STATE                     = nnnnn
INSTRUMENT_HOST_TEMPERATURE              = <array of 13 8-bit integers>
INSTRUMENT_TEMPERATURE                   = nnnn
AMBIENT_TEMPERATURE                      = nnnn
CONVERTER_CURRENT                        = nnn
CONVERTER_VOLTAGE                        = nnn
APXS_MECHANISM_ANGLE                     = nnn
APXS_COMMUNICATION_ERROR_COUNT           = nnnnnn

/* Pointers to Start Records of Objects in File */
^ALPHA                  = ("<product_id>.dat",x)
^PROTON                 = ("<product_id>.dat",x+1)
^XRAY                   = ("<product_id>.dat",x+2)
^BACKGROUND             = ("<product_id>.dat",x+3)

/* Object descriptions */
OBJECT                  = SPECTRUM
NAME                    = ALPHA
INTERCHANGE_FORMAT      = BINARY
ROWS                    = 1
ROW_BYTES               = 512
COLUMNS                 = 1
END_OBJECT              = SPECTRUM
```

Figure C. — *Template of Mars Pathfinder APXS EDR PDS Label File (continued)*

```
OBJECT                      = SPECTRUM
NAME                        = PROTON
INTERCHANGE_FORMAT          = BINARY
ROWS                        = 1
ROW_BYTES                   = 512
COLUMNS                     = 1
END_OBJECT                  = SPECTRUM

OBJECT                      = SPECTRUM
NAME                        = XRAY
INTERCHANGE_FORMAT          = BINARY
ROWS                        = 1
ROW_BYTES                   = 512
COLUMNS                     = 1
END_OBJECT                  = SPECTRUM

OBJECT                      = SPECTRUM
NAME                        = BACKGROUND
INTERCHANGE_FORMAT          = BINARY
ROWS                        = 1
ROW_BYTES                   = 512
COLUMNS                     = 1
END_OBJECT                  = SPECTRUM

END
```

2.2 File Naming Conventions

The following naming convention standard for IMP image data files is to be maintained by MIPS as a means of files management. It is suggested for all end-users of the products.

2.2.1 VICAR Image Data File Names

For all data files stored in the MIPS Working Mission Storage (WMS), the filenames will be constructed with five parts as shown below in Figure D.

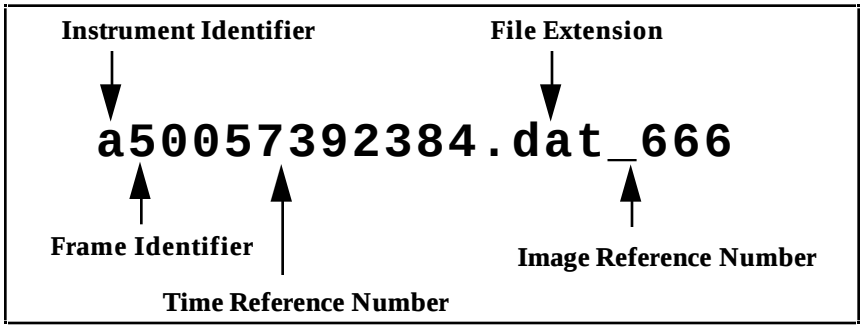

Figure D. — *Sample Spectrum Data File Name*

Instrument Identifier - The instrument identifier will always be the lowercase letter ‘a’, representing the APXS instrument.

Frame Identifier - The frame identifier will be a hexidecimal digit representing the number of accummulations associated with this data set.

Time Reference Number - The time reference number will be the 10-digit Spacecraft Clock Start Count, as described in the Appendix.

File Extension - The file extension is a three character mnemonic that will always be ‘dat’.

Image Reference Number - Finally, the image reference number is the Command Sequence Number appended onto the file extension.

2.2.2 PDS Data File Names

The PDS data filenames will be constructed with four of the five VICAR image data filenames components as shown below in Figure E.

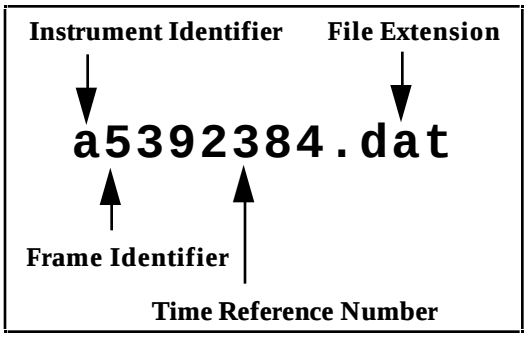

Figure E. — *Sample Spectrum PDS Data File Name*

Instrument Identifier - The instrument identifier will always be the lowercase letter ‘a’.

Frame Identifier - The frame identifier will a hexidecimal digit, refering to accummulation count associated with the data.

Time Reference Number - The time reference number will be the least significant 6-digits of the Spacecraft Clock Start Count (the 4 significant digits will be used as part of the directory hierarchy storing the image files).

File Extension - Finally, the file extension will always be the three character mnemonic ‘dat’.

2.2.3 PDS Label File Names

The PDS label filenames will be constructed with four of the five VICAR image data filenames components as shown below in Figure F.

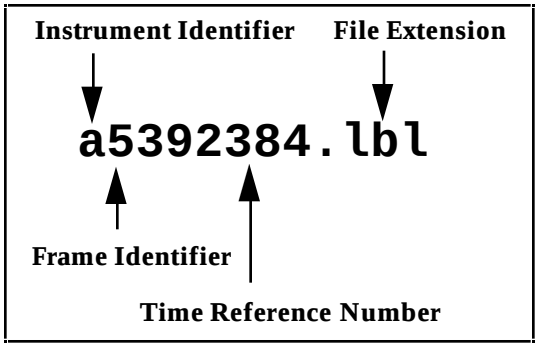

Figure F. — *Sample Spectrum PDS Label File Name*

Instrument Identifier - The instrument identifier will always be the lowercase letter ‘a’.

Frame Identifier - The frame identifier will a hexidecimal digit, refering to accummulation count associated with the data.

Time Reference Number - The time reference number will be the least significant 6-digits of the Spacecraft Clock Start Count (the 4 significant digits will be used as part of the directory hierarchy storing the image files).

File Extension - Finally, the file extension will always be the three character mnemonic ‘lbl’.

APPENDIX
APXS PDS/VICAR Label Items

The following pages list alphabetically the label items which are contained in the PDS and VICAR labels associated with each spectrum data file.